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Environmental study of water quality and some heavy metals in water, sediment and aquatic macrophytas in lotic ecosystem, Iraq

Marwa Ali Habeeb[1] **Abdul-Karim Kh. Al-Bermani[1]** **Jasim M.Salman[2*]**

1 Depertment of Biology ,Coll.of Science for women ,University of Babylon,Iraq.
2 Depertment of Biology ,Coll.of Science ,University of Babylon,Iraq

Corresponding author: rflower432@yahoo.com

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Abstract

This study was respect to detect possible environmental effects on the eastern Euphrates drainage from the Abo-Garak to south of Kifil city in Babylon province. Five sites were selected along the study area and Omit it during October 2013 to August 2014. Physical and chemical properties are measured (air and water temperature , pH , electrical conductivity , salinity, TDS ,TSS , BOD_5, dissolved oxygen , Alkalinity , Total Hardness , calcium , magnesium) and nutrients (nitrite , nitrate , reactive phosphate) as well as . The average of the studied heavy metals Fe , Cd , Pb and Cu the dissolved phase of water were 113.89 , 6.35 , 1.5 and 0.8µg /l for Fe , Cd , Pb and Cu , respectively .Heavy metals concentrations in the particulate form were 291.83, 9.39, 3.07 and 12.15 µg/g dry weight for Fe , Cd , Pb and Cu respectively. In the sediments, the concentrations of these heavy metals in the exchangeable phase were 318.66, 12.91, 6.27 and 13.23µg/g for Fe , Cd , Pb and Cu , respectively. While in the residual phase were 461.53, 5.29, 8.62 and 27.07 µg/g for Fe , Cd , Pb and Cu , respectively . The results revealed that the concentrations of heavy metals in water for the particulate phase were higher than in the dissolved phase , while in sediment, their concentrations in the residual phase were higher than their concentrations in the exchangeable phase except for Cd which was in the exchangeable phase higher than in the residual phase. The concentration and distribution of heavy metals in macrophytes *Ceratophyllum demersum* were (923.63 , 462.34 , 740.45 and 90.59)µg/g dry weight for Fe , Cd , Pb and Cu , respectively . While , (728.57, 162.17 , 244.13 and 118.87) µg/g dry weight for Fe , Cd , Pb and Cu , respectively. for Fe , Cd , Pb and Cu in *Hydrilla verticillata* .
The study area was very hard water and high BOD_5. The nutrients showed clear seasonal variation in their concentration

Keywords; Water quality, Heavy metals, Sediments, *Hydrilla verticillata*, lotic ecosystem.

Introduction

Waters pollution with heavy metals have many effects on aquatic organisms, in addition to the bioaccumulation and bioconcentration of these metals in the aquatic food chain put the consumers such as humans in risk [1]. Metals in aquatic system have many origin, distribution and accumulation of metals are influenced by mineralogical composition, sediment texture, adsorption processes and oxidation-reduction state and physical transport [2]. The contamination by heavy metals causes a serious problem may be due to low degradable in nature compared with organic pollutants and they accumulate in different parts of the food chain [3]. The geochemical composition of water body is largely governed by the physiochemical characteristics (pH, EC , DO, ect.) [4]. Various studies have demonstrated that aquatic system are contaminated by heavy metals in different areas of world [5]. Aquatic macrophytes have great potential to accumulate heavy metals inside their tissues. These plants can accumulate heavy metal concentrations 100,000 times greater than in the associated water [6]. Aquatic macrophytes are thought to remove metals by three patterns: metals are restricted from entering the plant and attach to the cell wall; metals are accumulated in the root, but translocation to the shoot is constrained; and hyper accumulation, in which metals are concentrated in the plant parts. The hyper accumulative capacities of aquatic macrophytes are beneficial for the removal of heavy metals [7]. This paper aimed to study the some physical-chemical properties and concentration of some heavy metals in water , sediments and two species of aquatic macrophtes (*Ceratophyllum demersum* and *Hydrilla verticillata*)

Materials and methods

Samples were collected monthly from five sites on Eastern Euphrates drain / middle of Iraq, (Fig1) from October 2013 to August 2014. Measure the physio-chemical parameters of water using clean polyethylene bottle (5L) as three replicates and filtered by using filter paper (Millipore filter paper 0.45 µm type fiber class). Air and water temperature were measured by Thermometers , pH by pH meter type WTW, Germany. Salinity examined according to Mackereth et al. [8]. TSS, TDS , DO , BOD_5 , Total Alkalinity measured according to APHA [9] .

In the laboratory nutrients were determined according to standard methods [10]. Nitrates was determined according to [11] and reactive phosphate was determined according to [12] explained by [13]. Aquatic plants collected from the middle of the drainage ,four selected heavy metals (Fe , Cd , Pb , Cu) were determined , the samples are analyzed according to [14], and measure by Flame Atomic Absorption Spectrophotometer type (Shimadze , AA-7000 . Japan) .

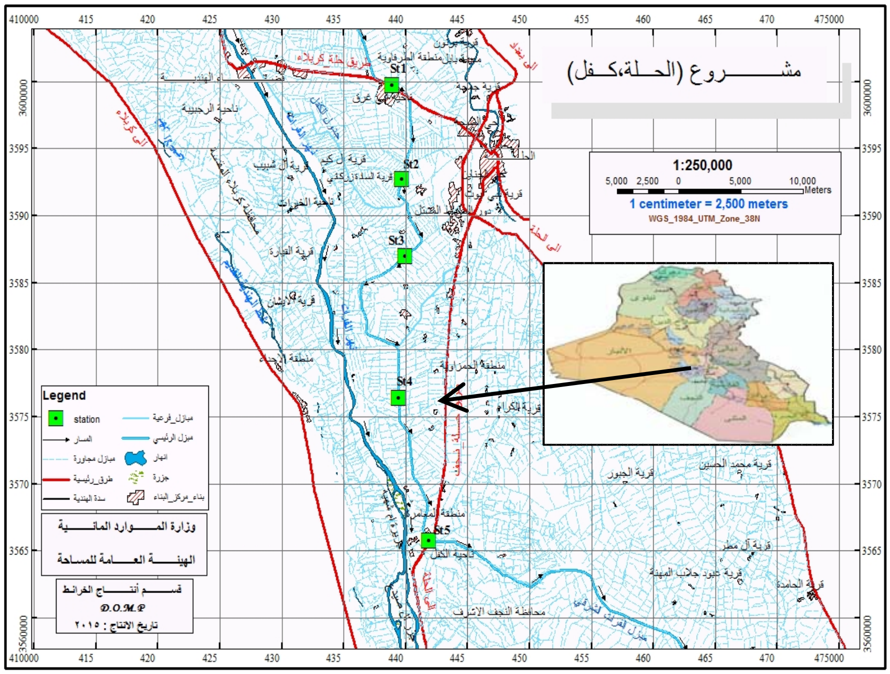

Fig.1: Map of study sites in eastern Euphrates drainage

Result and Dissection:

The physiochemical properties of the study sites are showed in (Table 1). The air and water temperature ranged between (6-46) ºC and (10-35) ºC, respectively it increase during hot months and decrease during cold months these results accepted with other Iraqi studies [15] . Electrical conductivity (EC) values ranged (4360-7400) µs/cm , it increase in winter and spring and in agriculture area because of washing of these area by rain water and increase level of water and dilution factor [16]. Salinity values ranged (2.97-4.73) ‰ according to these values the water of drain is salt because these area affected by agriculture and anthropogenic activities [17] .Total dissolved Solids showed high value ranged (2100-5270) mg/l as a result of washing area by rain water , it is accepted with studies [5, 18]. While Total suspended Solids showed lower values (0.03-0.97) mg/l because increase of level water and affected by dilution factor [16] . The pH of water is a measure of the hydrogen ion ($H+$) concentration in water, it is an important parameter for describing the state of chemical processes [19] . The pH values are affected by many factors such as temperature [19]. Other factors affect pH values were as the biological activity and $CO2$ concentration [20], the nature of climate [21], discharge of municipal and industrial wastewaters [22] pH values ranged (6.5-8) . Outside this range organisms exposed to stress as the low pH leads to the liberation of toxic compounds and elements from sediments to the water and then into plants and aquatic organisms [23]. Present study recorded high concentration of dissolved oxygen (5.8-11.5) mg/l . This may be due to

good mixing between the surface and bottom layers and high water levels [24]. While lower concentration of DO might be due to low water levels and decomposition processes of organic substance [24]. Biological Oxygen Demand (BOD5) used to determine the amount of oxygen consumer by microbial organism through aerobic oxidation of organic materials processes and convert to inorganic material [25] .The study showed high value through April/2014 in site (4) recorded (5.2) mg/L , it exceeded the international determinants allowed (5) mg/L [26] while lower concentration recorded through February/2014 in site (5) (1.02)mg/L , It is less than the international determinants and perhaps due to the launch of organic waste and ability of drain to self – treatment [27]. Total alkalinity values ranged (200-500) $mgCaCO_3/L$, the water of drain classified as high alkalinity. The concentrations of total alkalinity were affected by many factors such as organic pollution, rainfall which causes drifting the catchment area [28], and water levels [29] . The water of drain is very hard values ranged (800-2250) mgCaCO3/L , The high values of the hardness in the drain were related to the different factors: the geological nature of the lands that the drainage water passes through it [30] and the effect of agriculture and anthropogenic activities [31]. The concentrations of Calcium ion recorded were higher than Magnesium ion concentrations ; this might be due to the presence of calcium ion in a percentage higher than magnesium ion in the earth crust and soil [7]. The values of calcium ions ranged (160.32-601.2) mgCaCO3/l . While magnesium ion ranged (12.03-339.99) mgCaCO3/l High values of Magnesium ion in the water due to rainfall, while decreasing levels may be due to consumption of this ion by phytoplankton [32]. Nutrients one of the most important factor that affected the abundance and composition of aquatic plants communities [33]. Nitrogen omit it is the most abundant nutrient in fertilizer and enters the water by human and animal waste , as well as , agriculture land [34] . Nitrite values ranged (0.01-0.42) µg/l and the low concentration of nitrite concentration due to good aeration of drain water [35] . Nitrate is a common form of inorganic nitrogen in the aquatic environment [13], the present study recorded high concentration of nitrate in summer and spring due to high temperature that increase the concentration of dissolved salts and decomposition processes [36] . Phosphate one of the most nutrients that influenced on the growth and increase the cellular activity of phytoplankton but it is found in low concentration in aquatic environment [37] . The value recorded (N.D.-1.5) µg/l , it recorded high concentration through March/2014 in site (5) due to drain water influenced by agriculture activates [38] .

Chlorophyll-a one of pigments of photosynthesis present in most plants , algae and phytoplankton [39], the present study recorded (0.12-3.52) µg/L, high concentration of chlorophyll-a during summer and spring belong to algae blooms and phytoplankton and availability of temperature and nutrients and dissolved oxygen [40] while decrease concentration may be to decrease activity of aquatic organisms in cold months so there will be an abundance of oxygen and lack of production in phytoplankton [41] .

The concentration of the dissolved phase ranged between 113.89 µg/l for Fe and 6.35 µg/l for Cd and 1.5 µg/l for Pb and 0.8 µg/l for Cu (Table 2). Heavy metal concentration in dissolved phase were as follows Fe > Cd > Pb > Cu. Heavy metals recorded higher concentrations in summer (May, June, July and August .

While they recorded lower concentrations in winter (December, 2013 , January and February 2014) . The increase of their concentrations during summer may be due to high temperature, which increases the solubility of them. This conclusion is confirmed by a positive correlation between them and temperature. Also, might be due to decreasing the pH during summer that also increases their concentrations as confirmed by a negative correlation between them and pH [42]. While the decreasing of their concentration may be due to many factors such as water levels , alkalinity and also, formation complexes with organic matters [43], the amount of particulates and the density of phytoplankton [44]. Anthropogenic activities and throwing of wastes directly to the drainage water may also affect their concentrations [45, 41, 42].

The concentration of heavy metals in the particulate phase ranged (291.83, 9.39, 3.07 , 12.15) µg/g dry weight for each of of Fe ,Cd , Pb and Cu , respectively (Table 2). Their concentrations were as follows: Fe > Cu > Cd > Pb . The concentration of heavy metals in the particulate phase was higher than their concentration in the dissolved phase. This result might be due to the increased particulate matter in the drain, which include living and non - living components. The living components consist of planktons and other microorganisms, while the non – living organisms consist of silts and clay particles, in addition to organic and inorganic particles [46].

Sediments represent the final recipient of pollutants from natural and anthropogenic sources[51]. Thus, they are considered as a good Bioindicator for water pollution. They also, release the pollutants that contaminate them in the water column as a result of the effect of the physicochemical factors [47]. HMs in the sediments during this study were measured in the exchangeable and residual phases. Their concentrations in the exchangeable phase ranged from 318.66 µg/g for Fe and 12.91 µg/g for Cd and 6.27 µg/g for Pb and 13.23 µg/g for Cu . Their concentration's sequences were as follows: Fe > Cu > Cd > Pb . While their concentrations in the residual phase ranged from 461.53 µg/g for Fe and 5.29 µg/g for Cd and 8.62 µg/g for Pb and 27.07 µg/g for Cu and their concentration's sequences appeared as follows: Fe > Cu > Pb > Cd . (Table 2) Their concentrations in the residual phase were higher than their concentrations in the exchangeable phase except Cd was in the exchangeable phase higher than in the residual phase. These results might be due to the drainage of wastes directly into the drain Further more, as a result of decomposition and plant residues [14].

The present study recorded high concentration of heavy metals in the tissue of some aquatic plants compared with rates in the water and sediments .Their concentration in *C.demersum* ranged from 923.63 µg/g dry weight for Fe and 462.34 µg/g dry weight for Cd and 740.45 µg/g dry weight for Pb and 90.59 µg/g dry weight for Cu . Their concentration's sequences were as follows: Fe > Pb > Cd > Cu , while their concentration in *H.verticillata* ranged from 728.57 µg/g dry weight for Fe and 162.17 µg/g dry weight for Cd and 244.13 µg/g dry weight for Pb and 110.87 µg/g dry weight for Cu (Table 3). Their concentration's sequences were as follows: Fe > Pb > Cd > Cu. The aquatic plants are vary in accumulate heavy metals in their tissue, and many factors are effect on the heavy metals bioaccumulation as water quality , pollution source , growth form of plant [48] . Different accumulation abilities of species more or less depend on individual plants; nevertheless, some studies exist pointing out differences between the groups, e.g.

submerged and emergent species [49]. On the other hand, some authors do not confirm these differences [50]. A comparison of total metal uptake by the two plants showed that the greatest uptake of all metals from various concentrations was by the *C.demersum* excepted Cu is higher concentration in *H.verticillata* . Mechanisms of accumulation of heavy metals inside aquatic tissues that toxic elements linked to the walls of the cells in the roots or leaves , which prevents transmission through vegetable sap or it's expels to non – sensitive sites in the cell and stored in vacuoles [26] .

Table 1: Some physical - chemical properties of Eastern Euphrates drainage water for period from October 2013 to August 2014 [first line (range) and second line (mean ± S.D.)]

Parameters	Sites				
	Site1	Site2	Site3	Site4	Site 5
Air temp (C°)	7 – 46	8 – 44	6 – 45	9 – 45	7 – 43
	29.5± 14.34	29.6± 13.54	29.2± 13.72	29.1± 14.39	29± 13.27
Water temp (C°)	10 - 35	10 - 31	10 - 32	11 - 31	12 - 32
	22.1 ±8.38	21.13± 7.48	21.2± 8.28	21.3 ± 8.2	21.9± 7.96
EC (μs/cm)	4570-6690	4900-6650	4370-6730	4390-6580	4360-7400
	5582±779.84	5671±668.93	5752±717.98	5401.1±774.29	5401.1±843.36
Salinity ‰	2.92-4.28	3.13 – 4.25	2.89 – 4.3	2.8 – 4.21	2.79 –4.73
	3.60±0.49	3.65 ±0.42	3.73 ±0.45	3.57±0.48	3.65±0.65
TDS (mg/l)	2200-4690	2100-4700	2230-4780	2230-4640	2100-5270
	3670±727.3	3795±749.4	3859±760.8	3633±725.7	3786±805.3
TSS (mg/l)	0.04-0.84	0.05-0.93	0.03-0.88	0.04-0.93	0.03-0.97
	0.31±0.28	0.31±0.3	0.31 ±0.29	0.35 ±0.3	0.36±0.34
pH	7.5 – 8.6	7.8 – 8.7	7.8 – 8.6	7.8 – 8.7	7.8 – 8.6
	8.3± 0.31	8.4± 0.26	8.3±0.27	8.5±0.28	8.2±0.29
DO (mg/l)	6.3-11.5	6.8 – 10.8	5.8 – 11.5	6.3 – 10.2	6.5 – 9.4
	8.35±1.68	8.75 ±1.3	8.40 ±1.63	8.41±1.22	7.64±0.88
BOD5 (mg/l)	2.14 – 4.5	1.5 – 4.32	1.04 – 4	3.7 – 5.2	1.02 –4.8
	3.3±0.71	3.17 ±0.93	3.14 ±0.94	4.44 ±0.5	2.90±1.19
Total Alkalinity ($mgCaCO_3/l$)	300 - 450	300 - 450	250 - 500	200 - 350	350 - 450
	48.3±366.47	52.96±366.37	78.88±371.27	47.14 ±301.53	35.35±376.60
Total hardness ($mgCaCO_3/l$)	900-2200	900-2150	800-2200	800-2250	800-2200
	418.46±1563.4	390.9±1546.9	415.96±1380.8	526.94±1548.6	449.56±1422.7
Calcium ($mgCaCO_3/l$)	240.48-601.2	240.48-460.92	240.48-480.96	160.3-440.88	200.4-541.08
	389.52±113.04	338.31±80.98	326.12±87.14	287.77±96.6	325.63±103.98
Magnesium ($mgCaCO_3/l$)	48.51-276.39	72.83-266.79	48.56-254.99	12.03-291.47	48.51-339.99
	140.84±113.04	162.61±80.98	179.97±87.14	141.31±96.6	164.48±103.98
Nitrite (μg/l)	0.01 – 0.36	0.02 – 0.39	0.01 – 0.42	0.03 – 0.35	0.02 – 0.36
	0.14±0.12	0.14 ±0.11	0.16 ±0.14	0.14±0.12	0.1±0.1
Nitrate (μg/l)	14.4-25.14	12.28-22.71	13.14-31.01	11.85-20.85	10.71-20.28
	18.97±3.64	16.9 ±3.78	22.83±5.97	16.26±3.41	15.25±3.12
ReativePosphate (μg/l)	N.D – 1.52	N.D – 1.6	N.D – 1.63	N.D – 1.53	0.53 – 1.5
	0.8±0.49	0.84 ±0.49	0.73 ±0.53	0.89±0.53	1.05 ±0.73

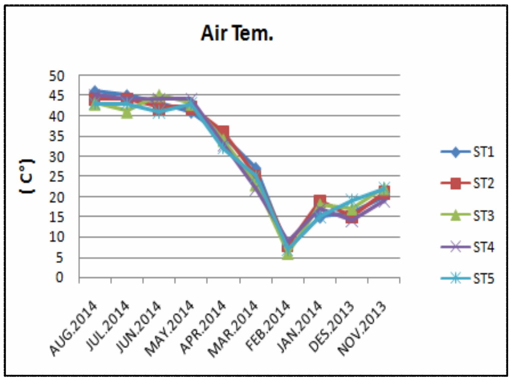

Figure 2 : Monthly variation of Air temperature during study period

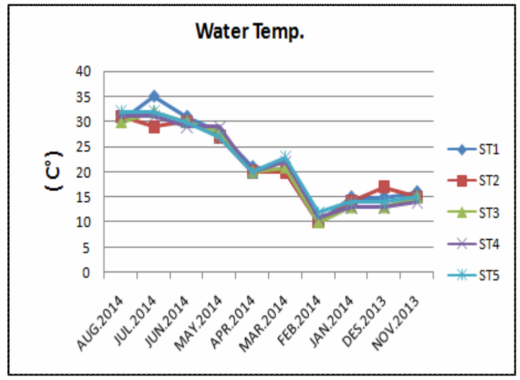

Figure 3 : Monthly variation of water temperature during study period

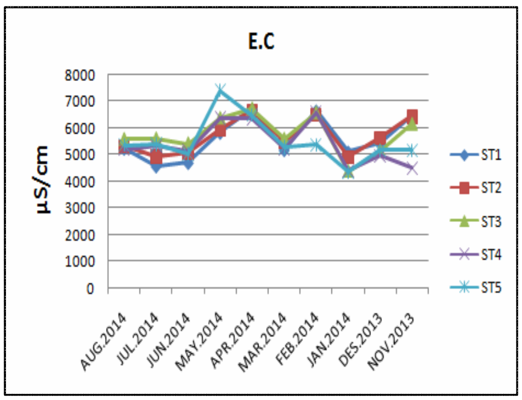

Figure 4: Monthly variation of Electrical conductivity during study period

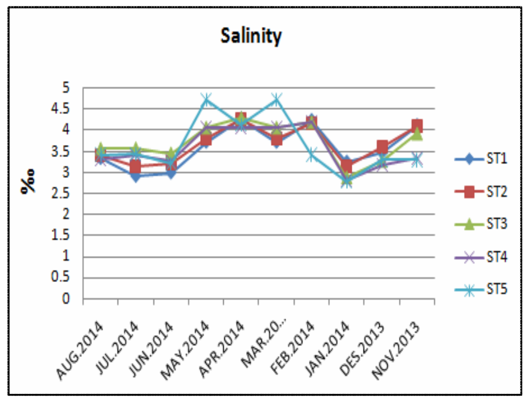

Figure 5: Monthly variation of Salinity during study period

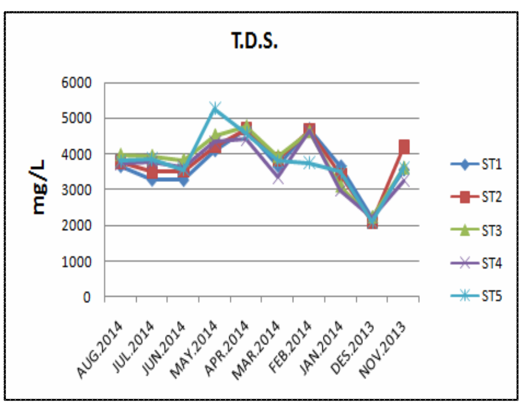

Figure 6: Monthly variation of Total Dissolved Solide during study period

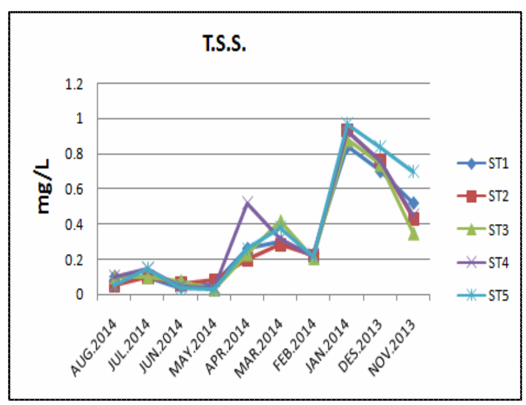

Figure 7: Monthly variation of Total Solid Suspended during study period

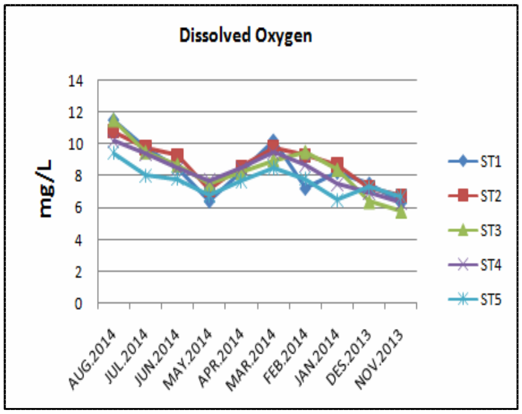

Figure 8: Monthly variation of Dissolved Oxygen during study period

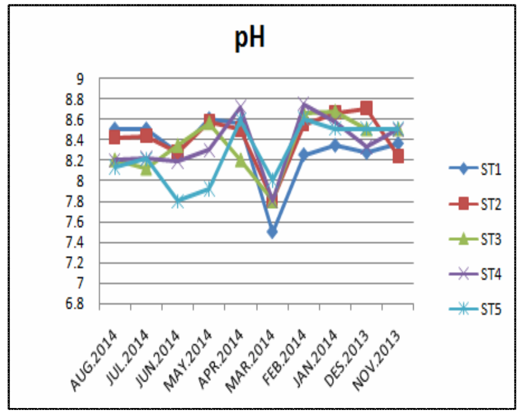

Figure 9: Monthly variation of pH during study period

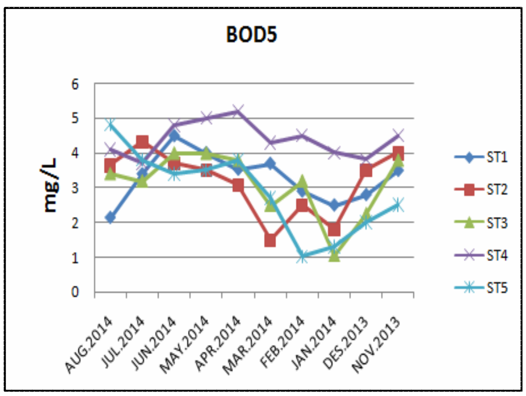

Figure 10: Monthly variation of BOD_5 during study period

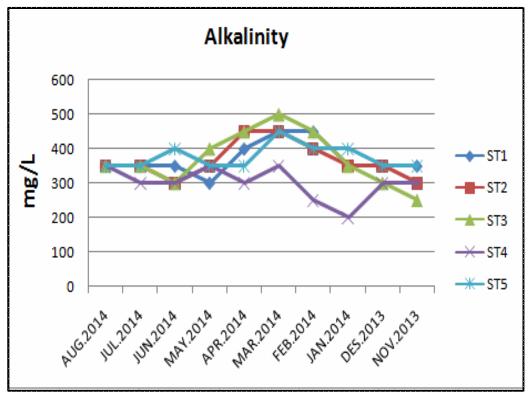

Figure 11: Monthly variation of Alkalinity during study period

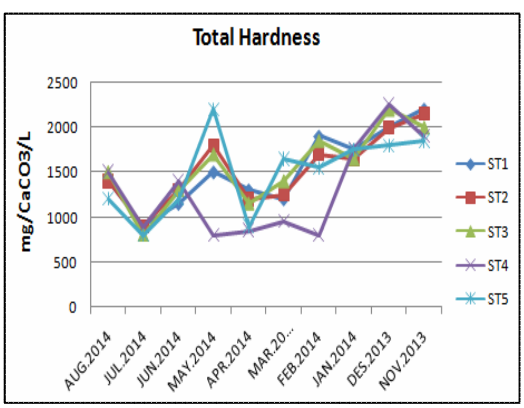

Figure 12: Monthly variation of Total Hardness during study period

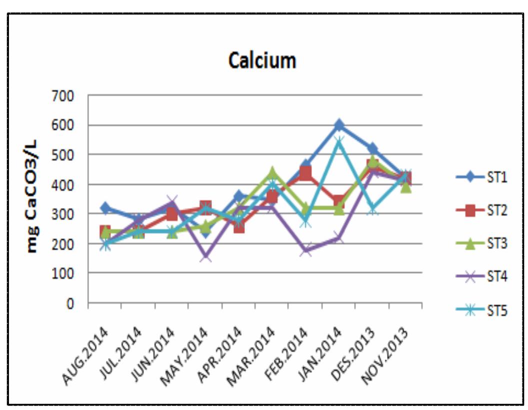

Figure 13: Monthly variation of Calcium during study period

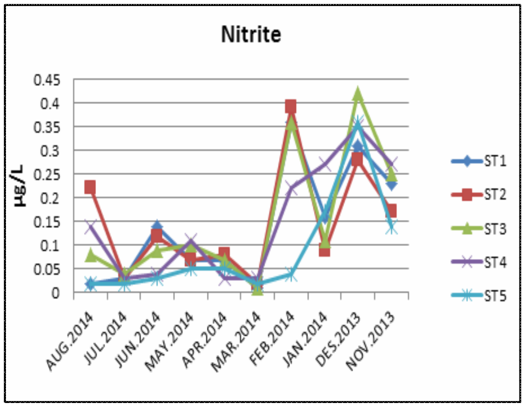

Figure 14: Monthly variation Nitrite during study period

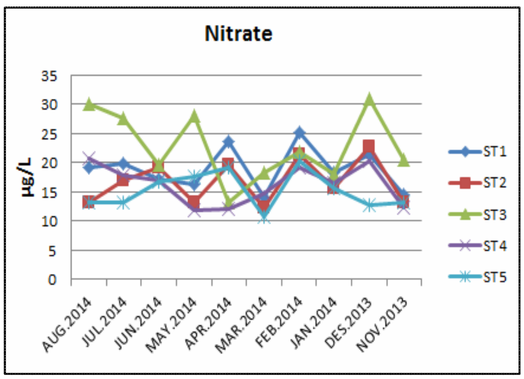

Figure 15: Monthly variation of Nitarte during study period

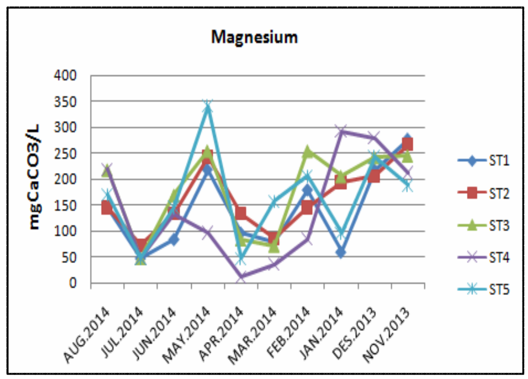

Figure 16: Monthly variation of Magnesium Hardness during study period

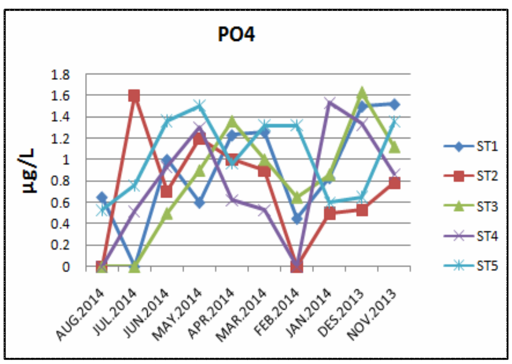

Figure 17: Monthly variation of Reactive Phosphate during study period

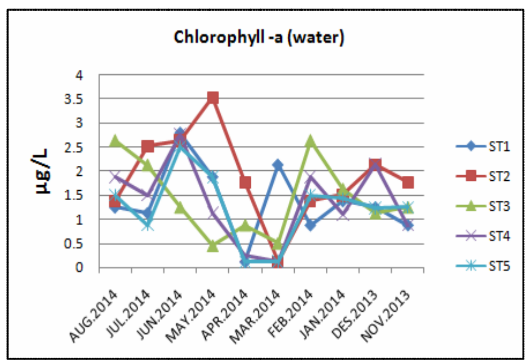

Figure 18: Monthly variation of Chlorophyll-a during study period

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Table 2: Concentration of some Heavy Metals in Water [Dissolved phase (µg/L) and Particulate phase (µg/g)] and in Sediment [Exchangeable Phase and Residual Phase (µg/g)] in the period from October 2013 to August 2014 first line (range) and second line (mean ± S.D.)

Elements		Sites					
		1	2	3	4	5	Average
Fe	D	89.36– 149.13	74.38–175.63	70.66 – 140	88.89-180.69	76.88-196.46	113.89
		105.4±20.47	109.16±28.04	113.13±21.23	126.6±27.21	115.13±41.14	
	P	110.29-361.57	106.56-560.57	100.9 -471.09	191.8-580.77	172.7-572.08	291.83
		320.4±73.13	308.92±159.62	303.9±118.34	267.5±136.86	258.26±138.29	
	E	100.61-531.28	103.64-581.79	200.8 - 530.38	100.6-530.33	103.08- 497.79	318.66
		289± 140.79	334.7± 146.38	228± 104.2	316.9± 139.17	429.9± 123.82	
	R	669.68-210.87	586.83-327.86	660.98-344.4	619.56-334.3	548.2-334.33	461.53
		446.4±156.82	439.6±81.09	398.1±114.27	481.4±94.23	532.13±84.11	
Cd	D	5.13-9.37	5.62– 7.64	6.12– 7.64	5.13– 7.64	4.72– 6.72	6.35
		6.61± 1.52	6.14± 0.57	6.48±0.46	6.22± 0.53	6.3± 0.63	
	P	8.15– 13.23	5.38– 13.42	8.32– 10.75	8.03– 12.23	6.52– 10.52	9.39
		9.26± 1.5	10.01± 2.75	9.33± 0.85	9.1± 1.32	9.24± 1.52	
	E	11.31– 15.63	10.26– 14.69	12.35–15.71	9.36-13.53	9.62– 16.73	12.91
		13.62±1.28	13.44± 1.48	12.30±1.15	12.72±1.36	12.48±2.48	
	R	5.43-7.53	4.08-6.52	4.92-6.75	3.08-4.83	4.53- 5.75	5.29
		5.31± 0.64	5.29± 1.55	5.69± 0.74	4.85± 0.63	5.35± 0.48	
Pb	D	1.36– 3.45	0.62– 1.73	0.7– 1.52	0.89– 2.08	0.62– 3.37	1.5
		1.43± 0.71	1.48± 0.35	1.45± 0.29	1.55± 0.34	1.63± 0.88	
	P	4.57 – 5.57	1.72– 3.6	1.3– 3.74	1.72– 3.8	1.29 – 3.61	3.07
		3.28± 0.59	3.32± 0.68	3.46± 0.81	2.79± 0.63	2.48± 0.68	
	E	4.21– 8.57	5.62 – 7.51	5.32 – 8.23	5.35 – 8.32	4.22 – 7.52	6.27
		6.49± 1.58	5.95± 0.67	6.11± 1.07	6.74±0.89	6.09± 1.11	
	R	7.52 – 10.43	7.41 – 9.54	6.32 – 10.52	7.26 – 10.45	6.51 – 10.31	8.62
		8.4± 0.93	9.10± 0.7	8.85± 1.82	8.64± 1.07	8.15± 1.21	
Cu	D	N.D- 9.7	1.14 – 6.58	1.14 – 6.83	N.D - 11.04	N.D - 5.32	0.8
		6.37±2.72	2.24±1.92	2.96±2.03	3.18±2.68	4.79±3.05	
	P	7.42 – 18.09	7.27 – 15.8	7.47 – 14.81	6.72 – 14.23	7.17 – 16.77	12.15
		12.95± 2.98	12.63± 2.43	13.47±2.98	11.8± 2.91	10.27± 2.68	
	E	12.08– 17.37	9.62– 18.4	10.36– 19.52	9.2-16.35	8.26-16.51	13.23
		14.41±1.73	15.04±3.06	13.57±2.51	13.7±2.81	10.97±2.28	
	R	23.12-31.02	21.37-37.24	19.62-35.51	15.07-27.58	22.83-35.73	27.07
		27.11±2.76	28.72±5.54	28.72±4.99	23.63±4.5	28.05±4.17	

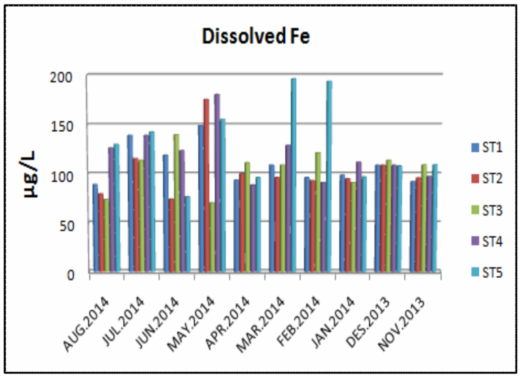

Figure 19: Monthly variation of Dissolved phase Fe during study period

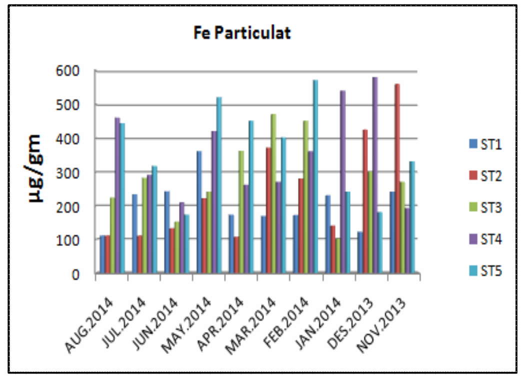

Figure 20: Monthly variation of Particulate phase Fe during study period

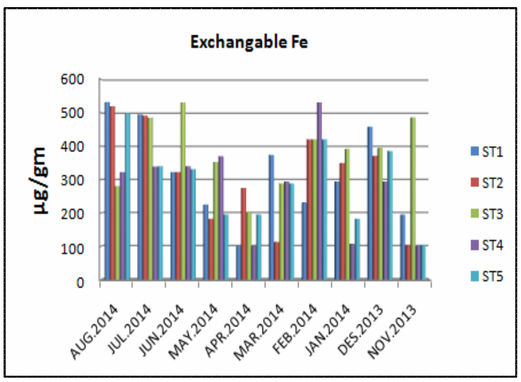

Figure 21: Monthly variation of Exchangable phase Fe during study period

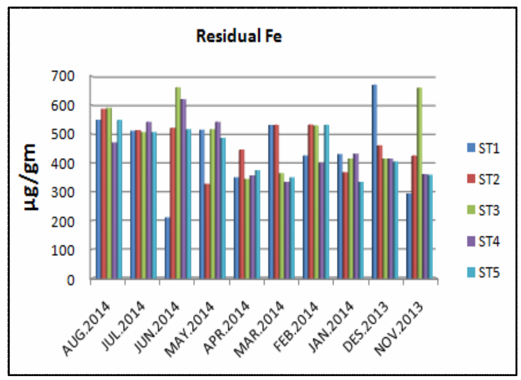

Figure 22: Monthly variation of Residual phase Fe during study period

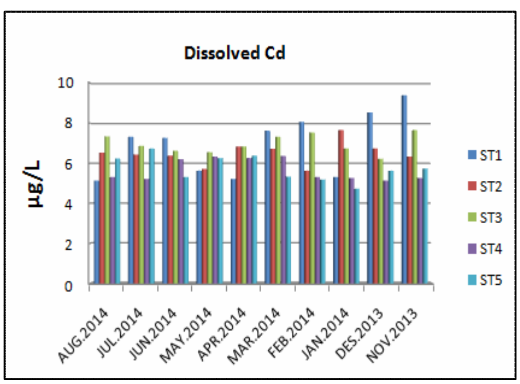

Figure 23: Monthly variation of Dissolved phase Cd during study period

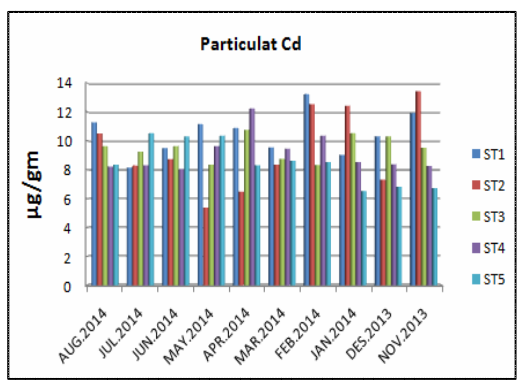

Figure 24: Monthly variation of Particulate phase Cd during study period

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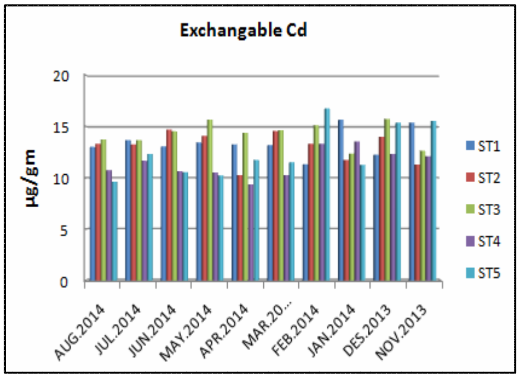

Figure 25: Monthly variation of of Exchangable phase Cd during study period

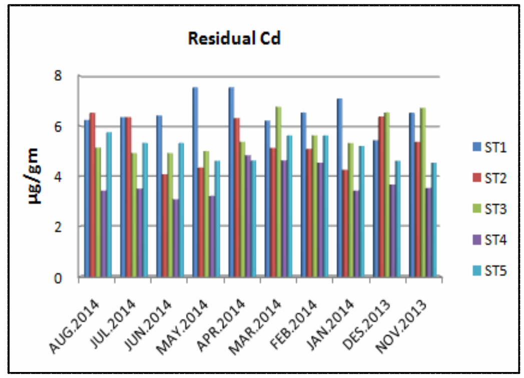

Figure 26: Monthly variation of of Residual phase Cd during study period

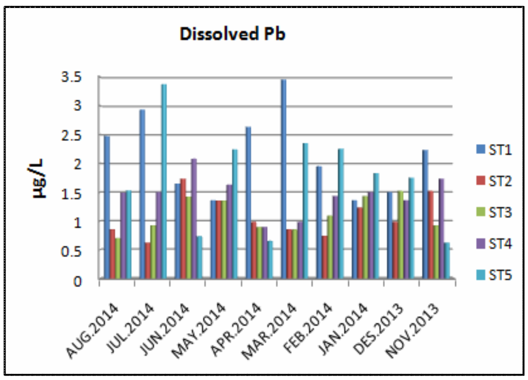

Figure 27: Monthly variation of Dissolved phase Pb during study period

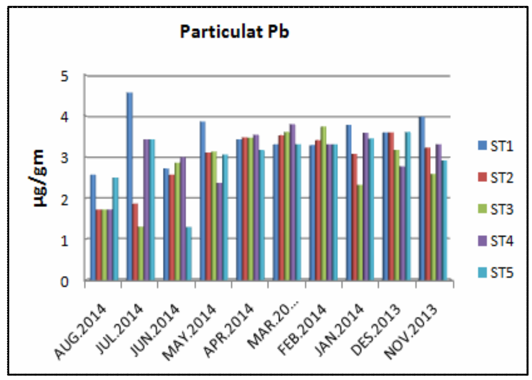

Figure 28: Monthly variation of Particulate phase Pb during study period

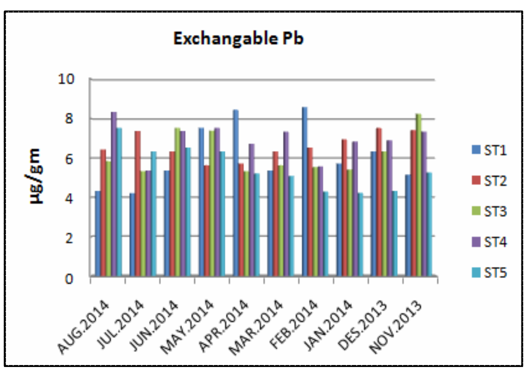

Figure 29: Monthly variation of of Exchangable phase Pb during study period

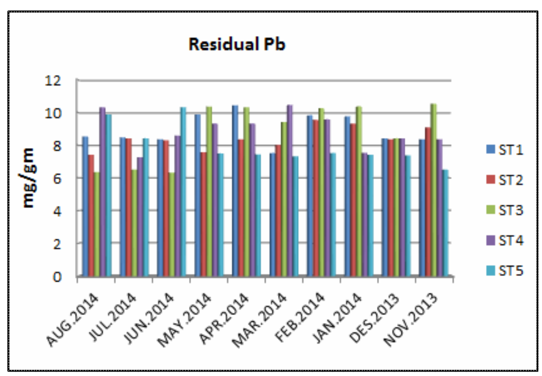

Figure 30: Monthly variation of of Residual phase Pb during study period

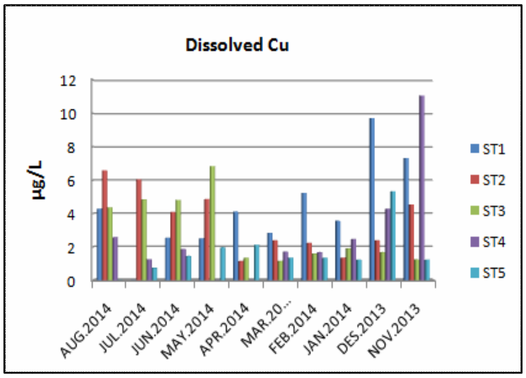

Figure 31: Monthly variation of Dissolved phase Cu during study period

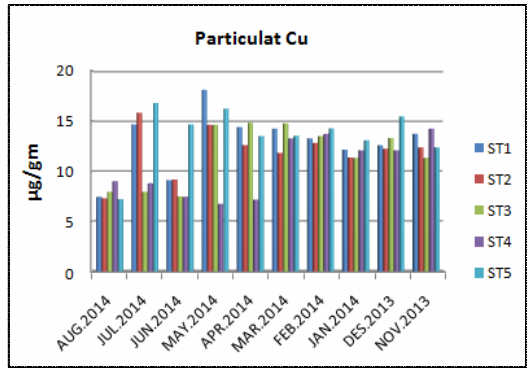

Figure 32: Monthly variation of Particulate phase Cu during study period

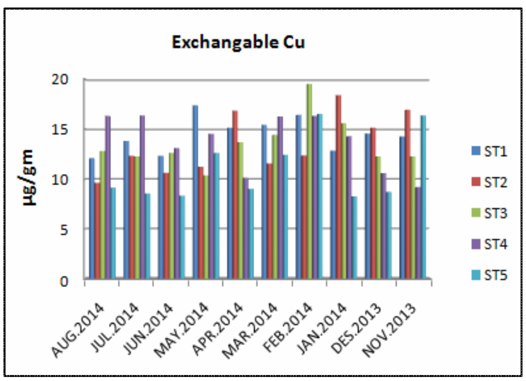

Figure 33: Monthly variation of of Exchangable phase Cu during study period

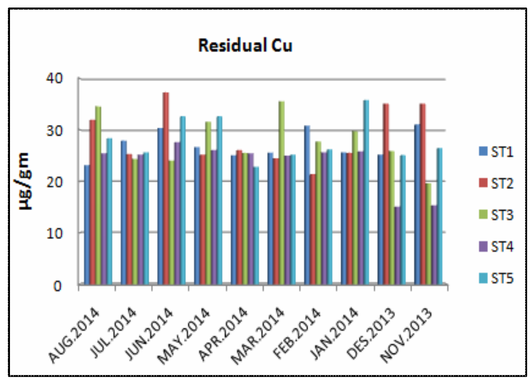

Figure 34: Monthly variation of of Residual phase Cu during study period

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Table 3: Concentration of Heavy Metals in *C.demersum* and *H.verticillata* (µg/g) in the period from October 2013 to August 2014 [first line (range) and second line (mean ± S.D.)]

Elements	Aquatic Plants	Sites					
		1	2	3	4	5	Average
Fe	*C.demersum*	446.47-1175.75	446.47-1276.75	563.61-1317.15	327.65-1153.53	527.65-1340.73	923.63
		918.3±274.44	895.16±261.02	937.37±238.88	931.7±229.59	935.61±219.35	
	H.verticillata	339.67-923.05	312.21-1078.24	321.04-978.24	527.65-1135.35	802.94-1246.47	728.57
		620.55±224.86	647.59±257.92	573.6±255.15	753.08±224.84	1048.05±131.27	
Cd	*C.demersum*	165.92-655.74	165.92-670.63	129.6-678.07	171.97-696.68	147.7-726.45	462.34
		452.79±156.48	480.13±191.66	485.91±210.98	441.73±182.87	461.16±217.32	
	H.verticillata	98.31-371.35	99.63-268.8	104.67-254.32	99.11-311.53	113.37-316.48	162.17
		171.18±100.52	137.11±49.77	148.36±45.78	158.83±77.51	195.39±69.03	
Pb	*C.demersum*	711.36-776.4	610.1-785.4	559.4-781.9	695.56-779.64	672.4-784.64	740.45
		746.55±23.89	610.0±50.34	721.01±64.69	741.19±34.73	759.93±31.93	
	H.verticillata	99.31-509.36	100.38-602.32	121.8-507.14	99.11-507.14	98.42-507.14	244.13
		255.23±147.89	266.74±160.51	261.51±142.66	224.75±126.94	212.43±121.12	
Cu	*C.demersum*	67.83-125.32	68.55-98.1	79.82-105.32	73.88-129.61	80.61-131.04	90.59
		94.10±19.13	81.94±9.43	90.24±10.48	93.05±15.37	93.61±15.34	
	H.verticillata	42.43-171.04	41.64-183.42	65.1-187.8	55.1-171.04	122.04-184.29	110.87
		90.17±44.19	96.01±44.10	108.67±46.38	99.35±30.65	160.14±25.06	

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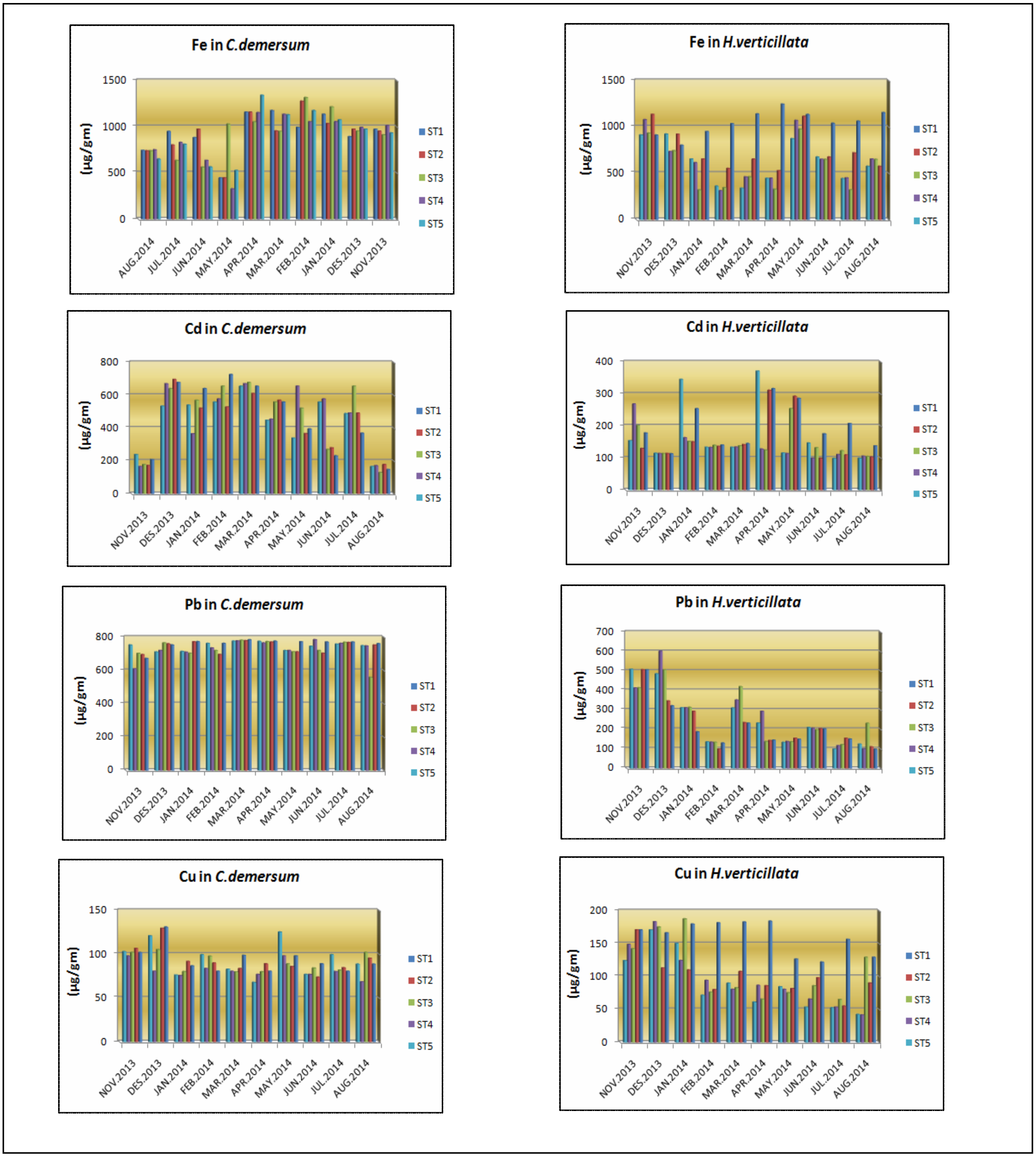

Figure 35: Monthly variation of Heavy Metals in in *C.demersum* and *H.verticillata* during study period

Conclusions

- Drainage water was light alkalinity ; hardness ; oligohaline ; high concentrations of suspended solids and high concentrations of nutrients.
- There are differences in the distribution of heavy metals between dissolved and particulate phase of water , concentration in particulate phase recorded higher than concentration in dissolved phase in all months of the study.
- High concentrations of heavy metals in *Ceratophyllum demersum* and *Hydrilla verticillata* in the study area. The highest concentrations of heavy metals in water and sediments as a result to impact of agriculture and urban discharge
- From the results of the present study, the aquatic plants under study can be used as a good bioindicator to water pollution by heavy metals.

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